Camada(s) Limite Planetária(s)

Planetary boundary layer(s)

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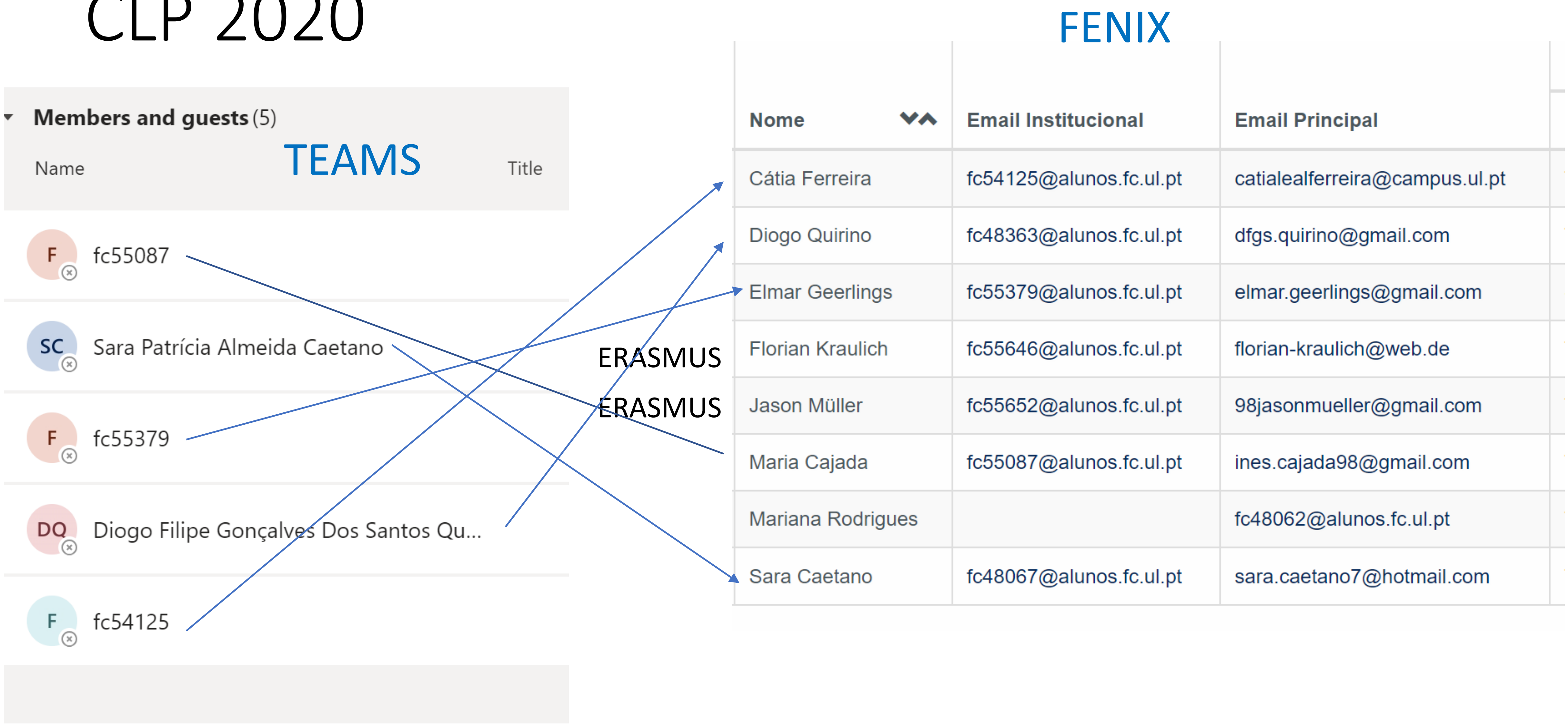
CLP 2020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Lectures

Lecture: Monday 14:00 – 15:45 (8.2.04)

Work sessions: (now Mon 16-18)

- I want you to present short exercises in this sessions (15min each each session)
- Those will be evaluated and contribute to 8/20 in the final mark
- I propose to do the sessions in teleconference in a different time slot
- (suggestions: Wednesday 14-16; Friday 10-12?) Think about this

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An Introduction to

Boundary Layer Meteorology

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What is your background

Present your selfes: what do you want from this course?

Refer what courses you did in: Fluid Mechanics, Thermodynamics, Meteorology, Oceanography

What contact did you have with the following concepts:

(a) Navier-Stokes equation
(b) Turbulence
(c) Dispersion
(d) Boundary Layer

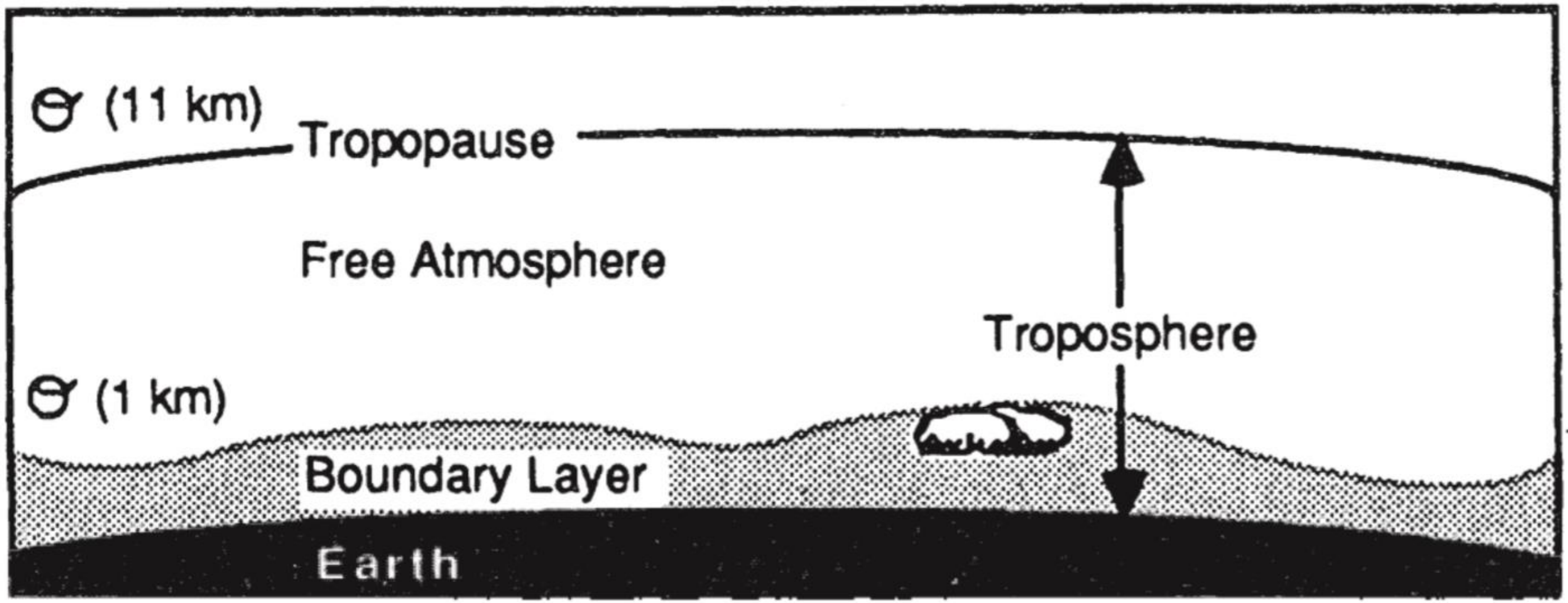
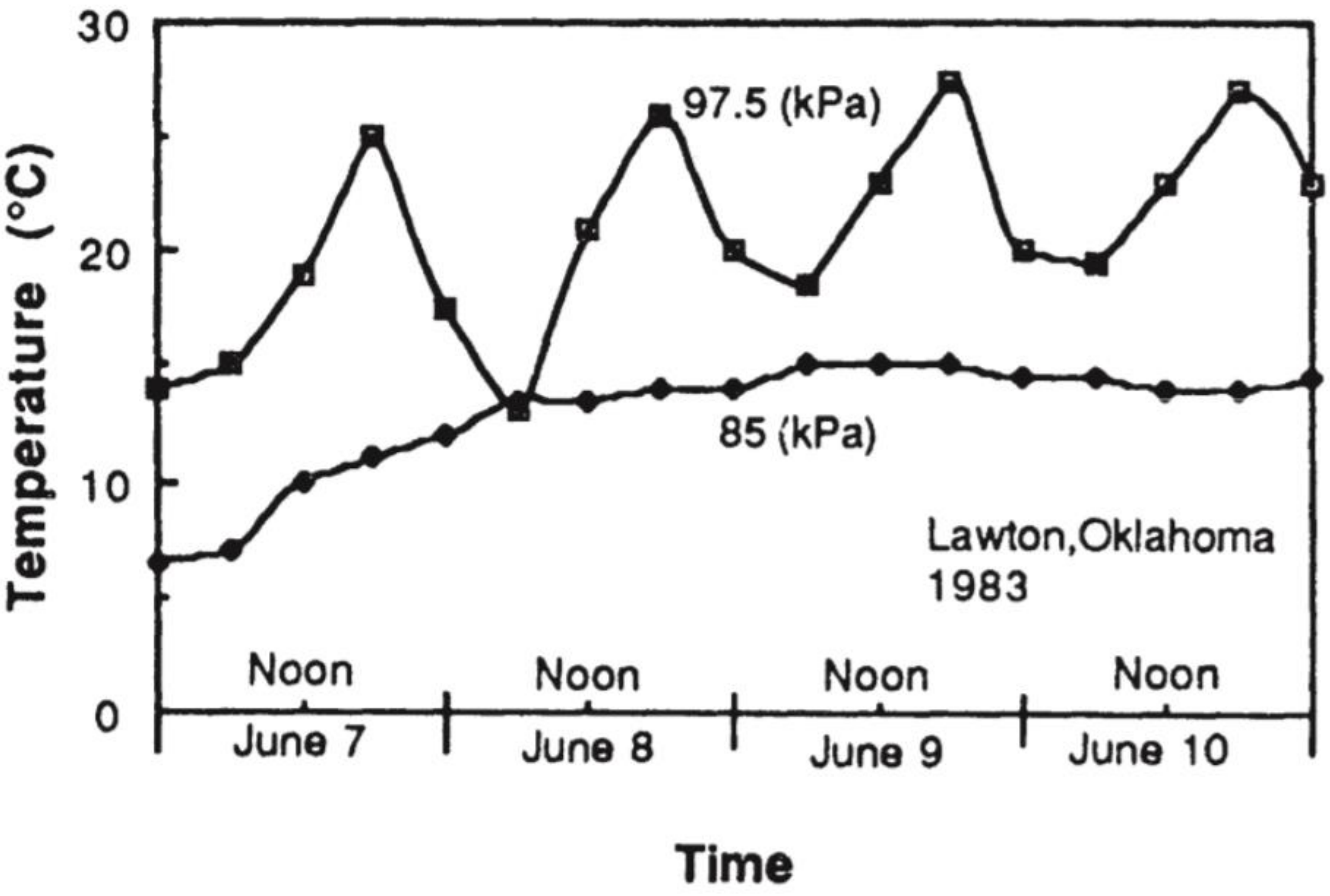


Fig. 1.1 The troposphere can be divided into two parts: a boundary layer (shaded) near the surface and the free atmosphere above it.

A camada limite responde à superfície em $\Delta t \approx 1h$

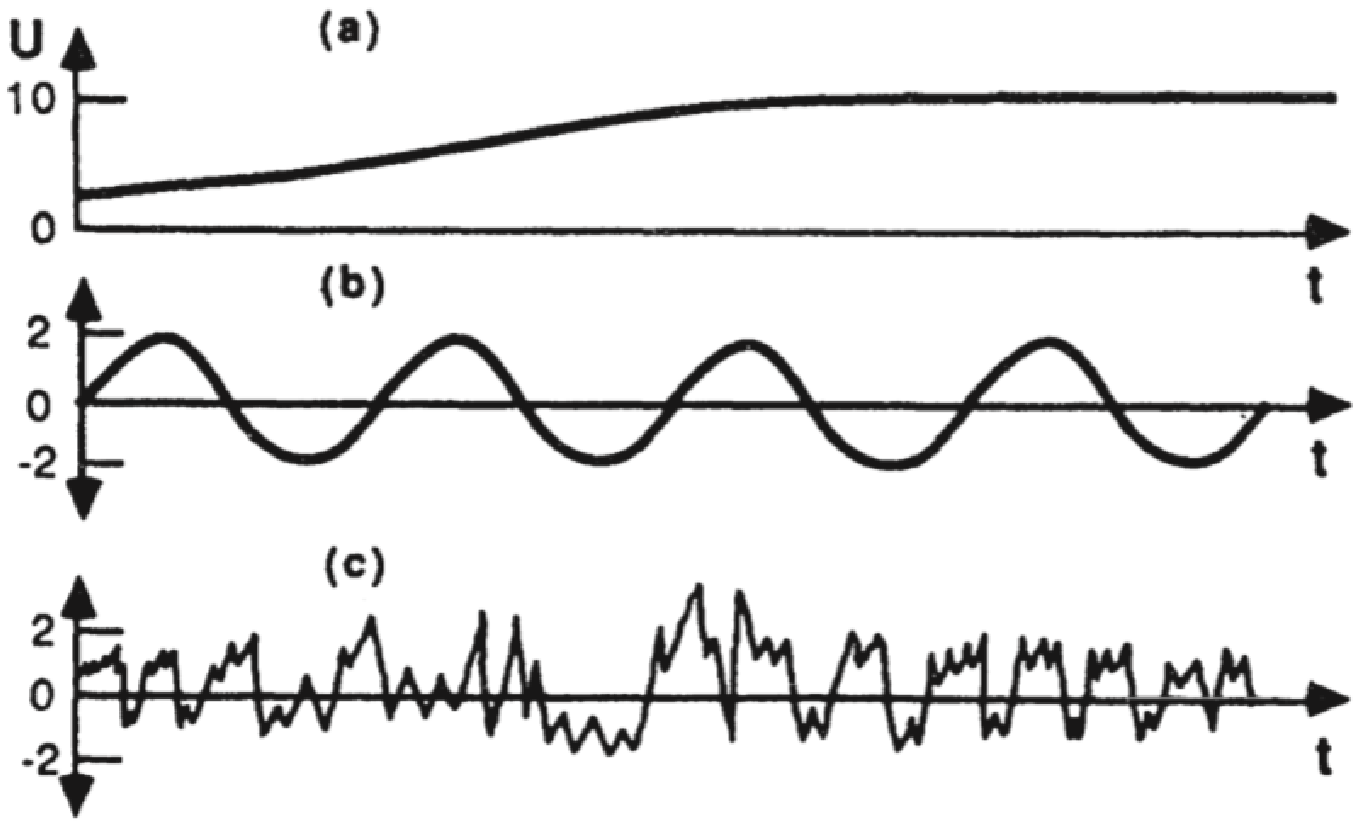
Fig. 1.2

Evolution of temperatures measured near the ground (97.5 kPa) and at a height of roughly 1100 m above ground (85 kPa). Based on rawinsonde lauches from Ft. Sill, OK.



Vento médio, ondas, turbulência

Fig. 1.3
Idealization of (a) Mean wind alone, (b) waves alone, and (c) turbulence alone. In reality waves or turbulence are often super-imposed on a mean wind. U is the component of wind in the x-direction.



Hipótese de Taylor

$$\frac{\partial \theta}{\partial t} = -\vec{v}.\nabla\theta(+fontes\ )$$

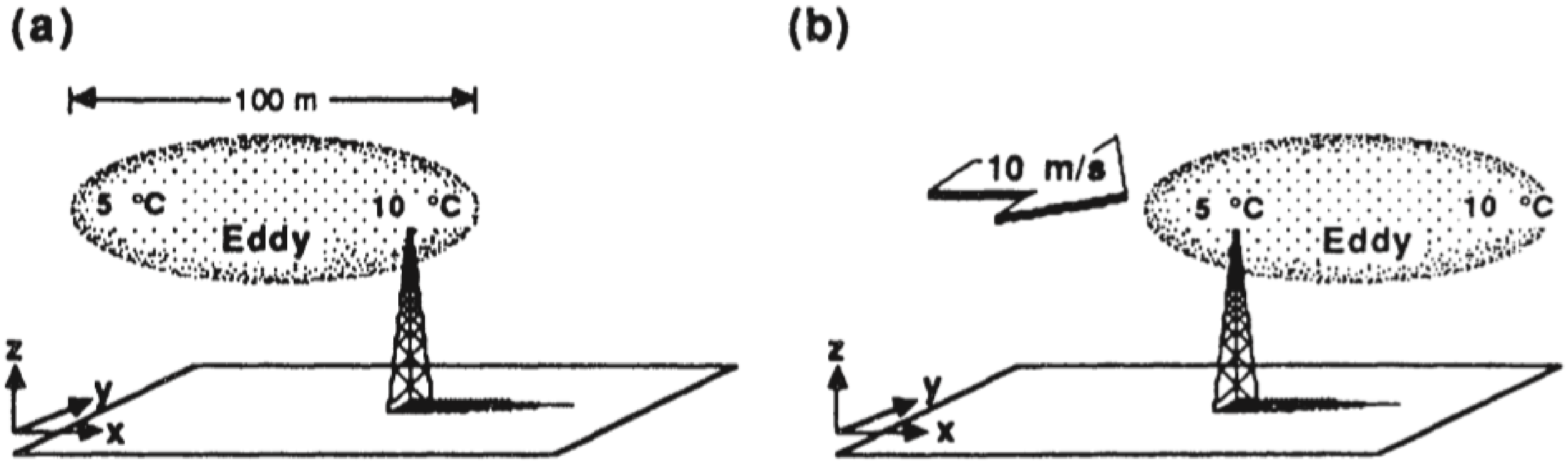


Fig. 1.4 Illustration of Taylor's hypothesis. (a) An eddy that is 100 m in diameter has a 5 ° C temperature difference across it. (b) The same eddy 10 seconds later is blown downwind at a wind speed of 10 m/s.

Ciclo diurno da CLP sobre terra em anticiclone

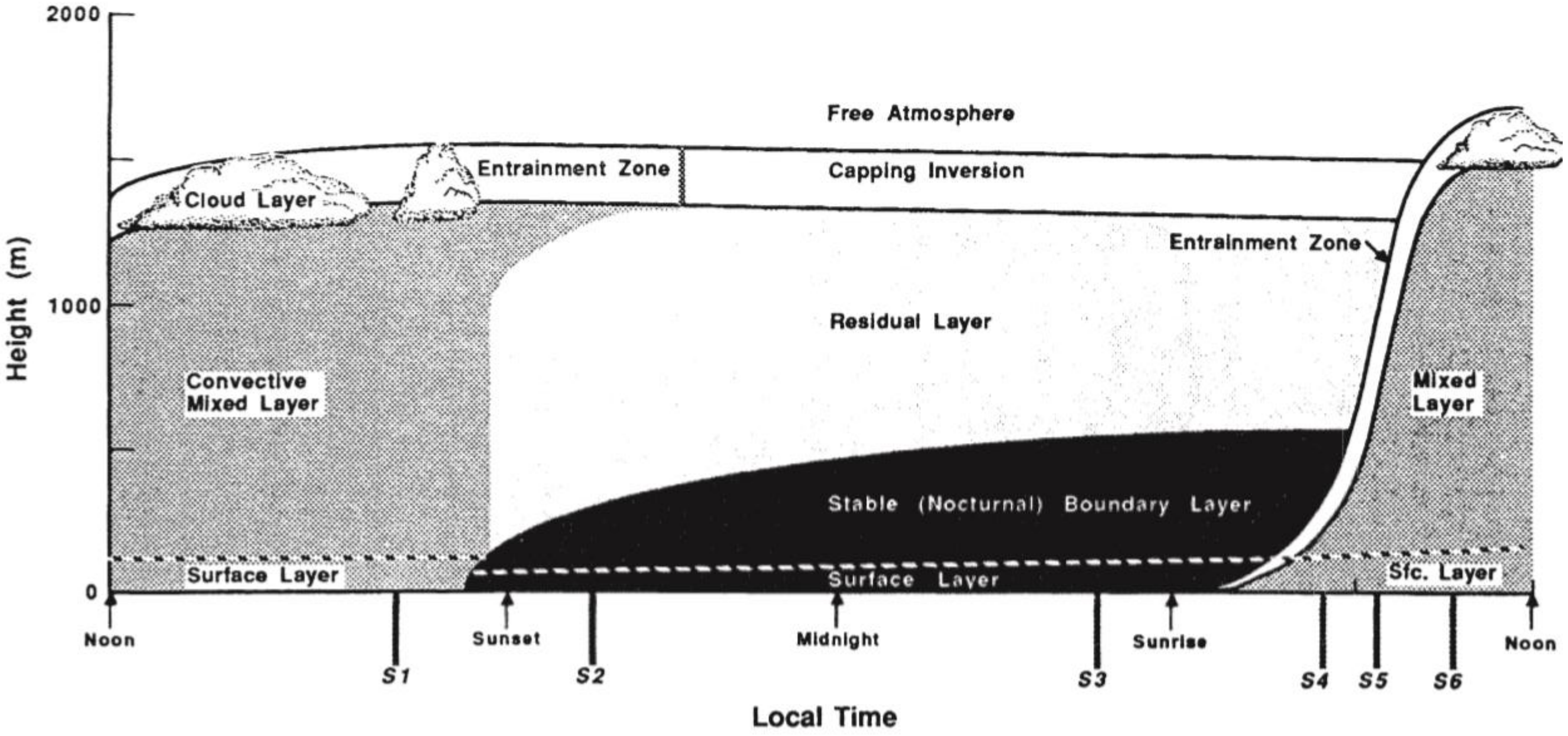


Fig. 1.7 The boundary layer in high pressure regions over land consists of three major parts: a very turbulent mixed layer; a less-turbulent residual layer containing former mixed-layer air; and a nocturnal stable boundary layer of sporadic turbulence. The mixed layer can be subdivided into a

Perfis observados (médios, diurnos)

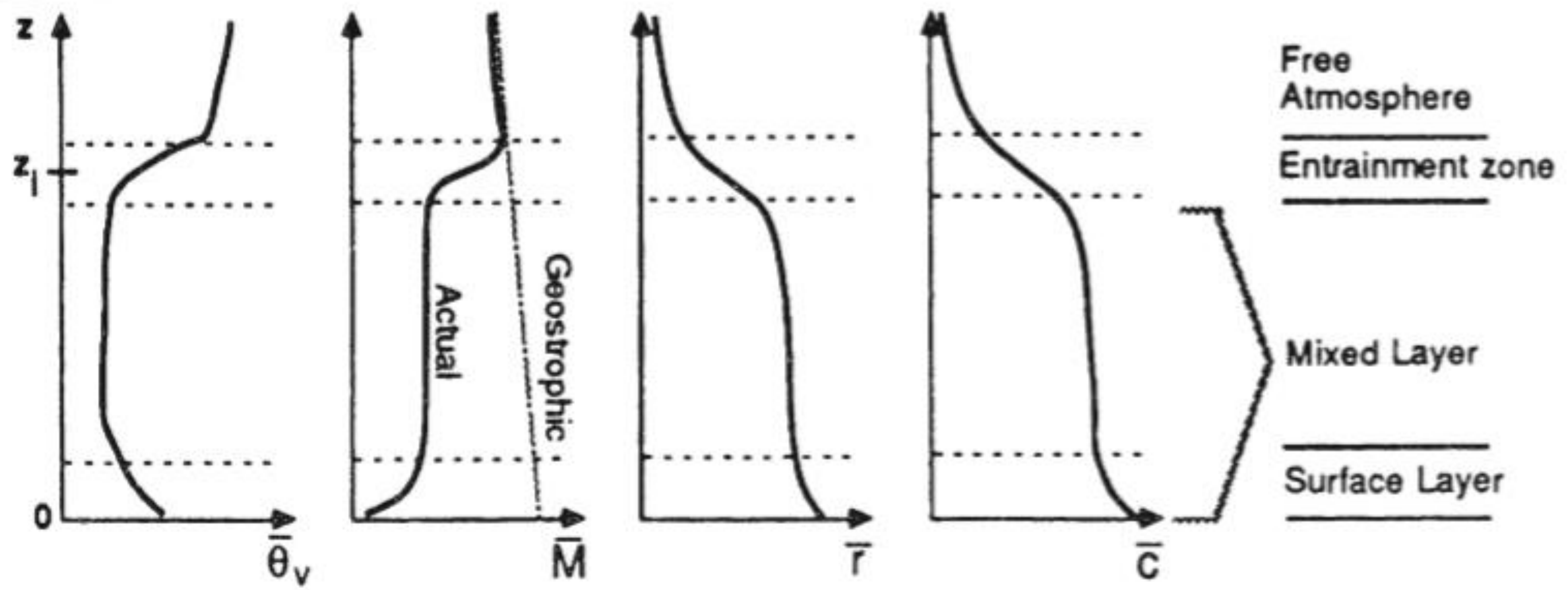
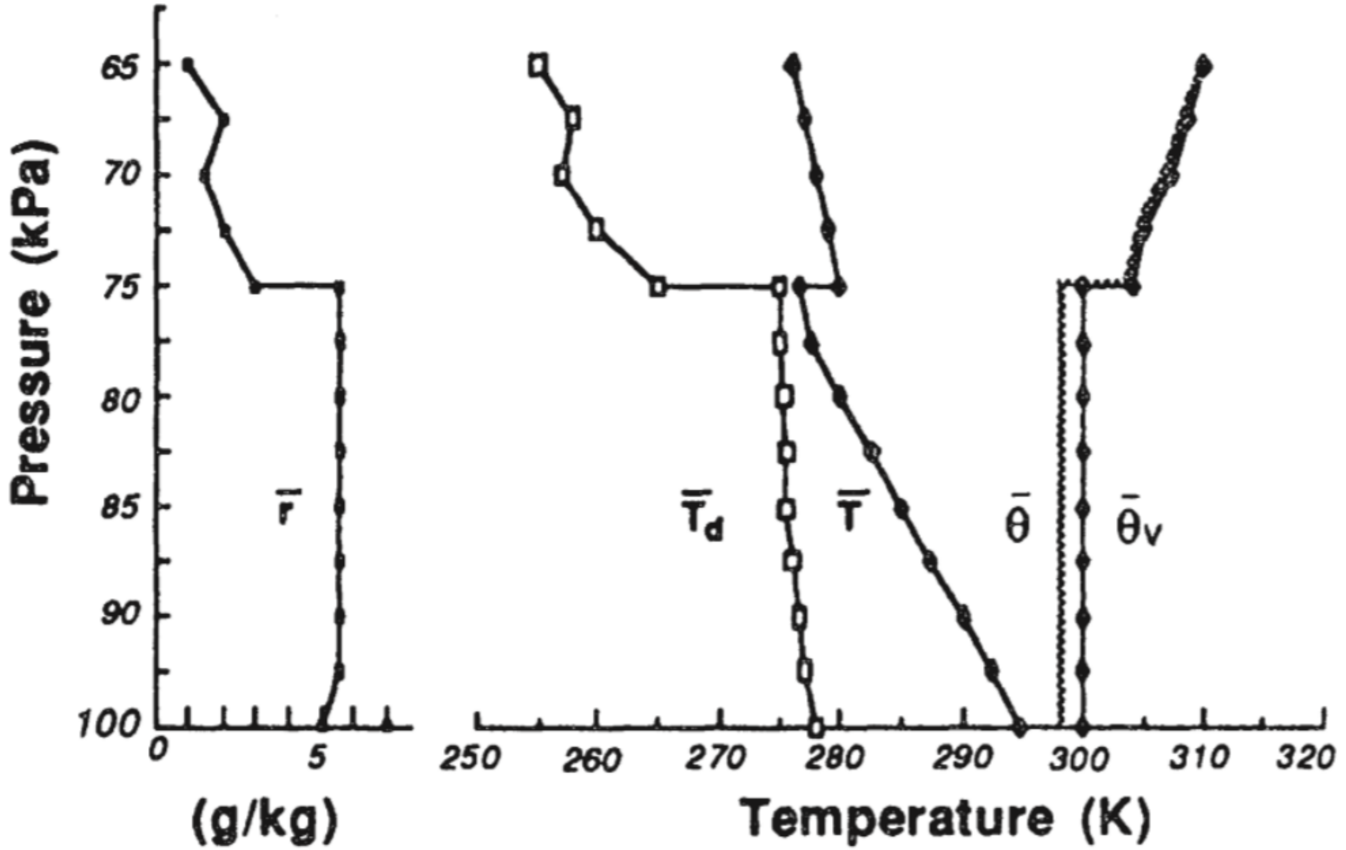


Fig. 1.9 Typical daytime profiles of mean virtual potential temperature $\overline{\theta}_v$, wind speed $\overline{M}$ (where $\overline{M}^2 = \overline{u}^2 + \overline{v}^2$), water vapor mixing ratio $\overline{r}$, and pollutant concentration $\overline{c}$.

Day time

Fig. 1.5
Example of the difference between mean potential temperature, $\bar{\theta}$, and mean virtual potential temperature, $\bar{\theta}_v$, given observations of mixing ratio, $\bar{r}$, and absolute temperature, $\bar{T}$. Dew point, $\bar{T}_d$, is also shown.



Night

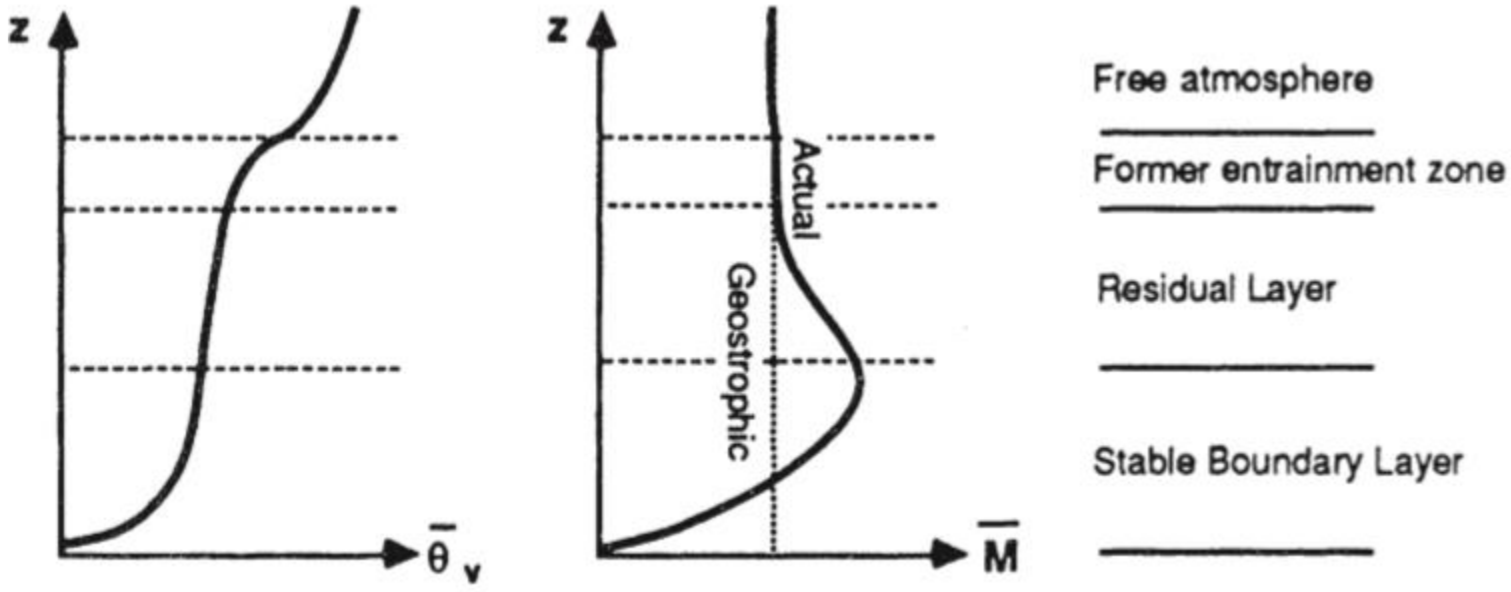


Fig. 1.11 Mean virtual potential temperature, $\overline{\theta}_v$, and wind speed, $\overline{M}$, profiles for an idealized stable boundary layer in a high-pressure region.

The equations (simplest case: 10 eq, 10 unknowns, continuum)

$$\frac{\partial \vec{v}}{\partial t} = -\vec{v}.\nabla\vec{v} - \frac{1}{\rho}\nabla P + \vec{g} - 2\vec{\Omega} \times \vec{v} + \nu\nabla^2\vec{v}$$ *Navier-Stokes*

$$\frac{\partial \theta}{\partial t} = -\vec{v}.\nabla\theta + \dot{Q}_{rad} + \dot{Q}_{lat} + \kappa\nabla^2\theta$$ *Termodinâmica*

$$\frac{\partial \rho}{\partial t} = -\nabla.(\rho\vec{v}) = -\vec{v}.\nabla\rho - \rho\nabla.\vec{v}$$ *Continuidade*

$$\frac{\partial q_{v,l,s,\dots}}{\partial t} = -\vec{v}.\nabla q_{v,l,s,\dots} + G_{q_{v,l,s,\dots}} + \kappa_D\nabla^2 q_{v,l,s,\dots}$$ *Fases da água*

$$p = R_d\rho T(1 + 0.61\, q_v)$$ *Eq de Estado*

$$\theta = T\left(\frac{P}{P_{00}}\right)^{-\frac{R_d}{c_p}}$$ *Temp. potencial*

$$\frac{\partial \vec{v}}{\partial t} = -\vec{v}.\nabla\vec{v} - \frac{1}{\rho}\nabla P + \vec{g} - 2\vec{\Omega} \times \vec{v} + \nu\nabla^2\vec{v}$$

Surface interactions act through the lower boundary condition.

Only second order term: $\nu\nabla^2\vec{v}$ (this will impose the no-slip)

No-slip $(u, v \equiv 0, em\ z = z_0)$: due to viscosity ν.

Viscosity is relevant for BIG $\nabla^2\vec{v}$ (ν is very small): z<1 mm! Laminar (viscous) sublayer.

However the PBL is also produced by other processes, namely by turbulent (not viscous) transport at the lower boundary.